United States Department of Agriculture
Forest Service
Rocky Mountain Research Station
Boise Aquatic Sciences Lab

# The Geomorphic Road Analysis and Inventory Package (GRAIP) Office Procedure Manual

## QUICK REFERENCE GUIDE

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# SECTION I: USING PATHFINDER OFFICE

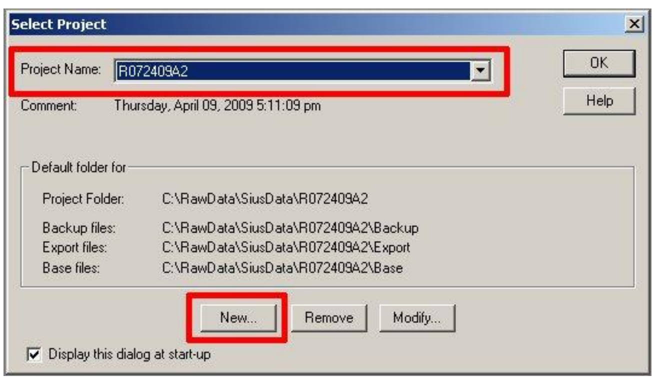
This section lists the steps within Pathfinder Office that must be completed before any other work is completed. You must transfer the TerraSync rover files into the SSF format, then differentially correct those files, creating a new set of files in the COR format. The COR files are finally exported as GIS shapefiles, and GRAIP analysis can begin.

## Transferring Files

**1.** Move or copy all of the relevant raw data into whichever folder your want to use.

- **a.** Relevant data are all nine TerraSync files for each file name (extensions .car, .dd, .gic, .gip, .gis, .giw, .gix, .obs, and .obx.; e.g. R071215A.car, R071215A.dd, etc.).
- **b.** Keep the raw data separate from the GIS workspace.

**2.** In Pathfinder Office, select the project folder.



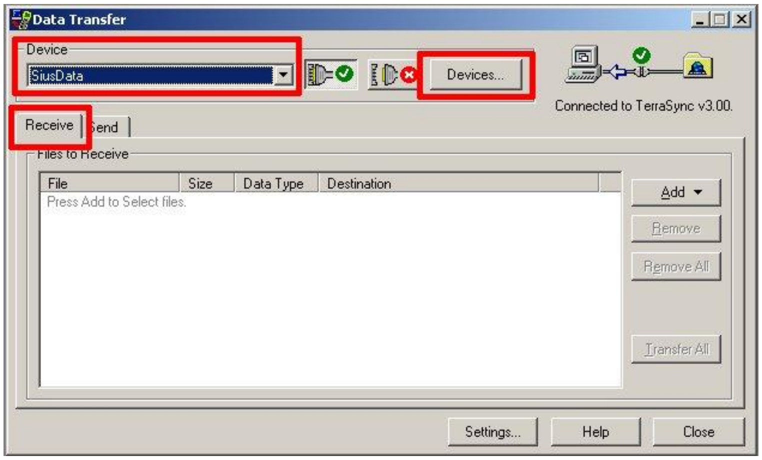

- **a.** If the *Select Project* window does not automatically open, go to *File-> Projects….*
- **b.** If you are working with an already created project, use the *Project Name* drop-down menu to select it and click *OK*. Skip ahead to step 4.
- **c.** If you do not have a folder set up for the current project, set one up now. Go to *New….*
  - **i.** Click *Browse* next to the *Project Folder* field-> navigate to the location of the raw data files and select the folder that contains those files-> click *OK*.
  - **ii.** The *Backup Folder*, *Export Folder*, and *Base File Folder* are subfolders automatically created in the project folder. Check to make sure they will be created in the same place by clicking *Browse…* next to one of those fields.
  - **iii.** In the *Project Name* field, enter an appropriate name.

**iv.** Click *OK* to create the project folder.

– Click *Yes* if the error message that says, "Folder already exists; Do you want to continue?" pops up.

**d.** Click *OK* to select the new project.

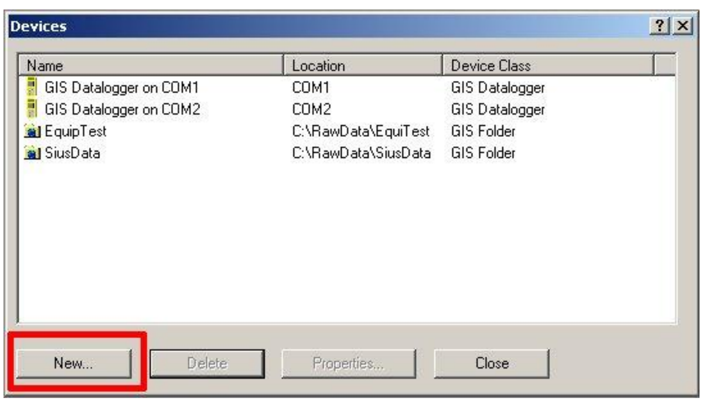
**3.** Go to the main menu-> *Utilities*-> *Data Transfer…*




**a.** Pathfinder Office is set up to get data directly from whatever device you use to collect field data, but we want to use data already on the hard drive of the computer. These methods are un-intuitive because of this.

**b.** Ensure that the *Receive* tab is selected.

**c.** If you already have the relevant folder connected, click on the *Device* drop-down to select it and skip to part (c). If you do not already have the relevant folder connected, you will need to connect it. Click *Devices…*.

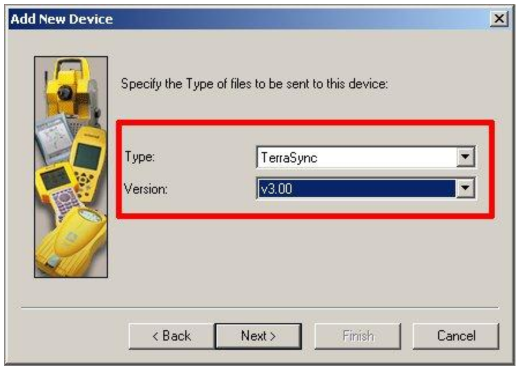



**i.** Click *New…*.

**ii.** Select *GIS Folder* as the type of device you wish to create-> click *OK*.

**iii.** Click *Browse…* to navigate to and select the *Project Folder* (created above)-> click *Next*.

**iv.** Use the drop-down menu next to *Type* to select *TerraSync*, and then select the *Version* closest to that used in the field-> click *Next*.




**v.** Give the device a short name (under nine characters) in the *Name* field-> click *Finish*. Click *Close* to close the *Devices* window.

**d.** Click the *Add* drop-down in the *Data Transfer* window-> wait for Pathfinder to connect to the device folder if necessary-> click *Data File*. Select the relevant data files (only those with a .gis extension show up)-> click *Open*. Those files are added to the *Files to Receive* field.

**e.** Click *Transfer All*.

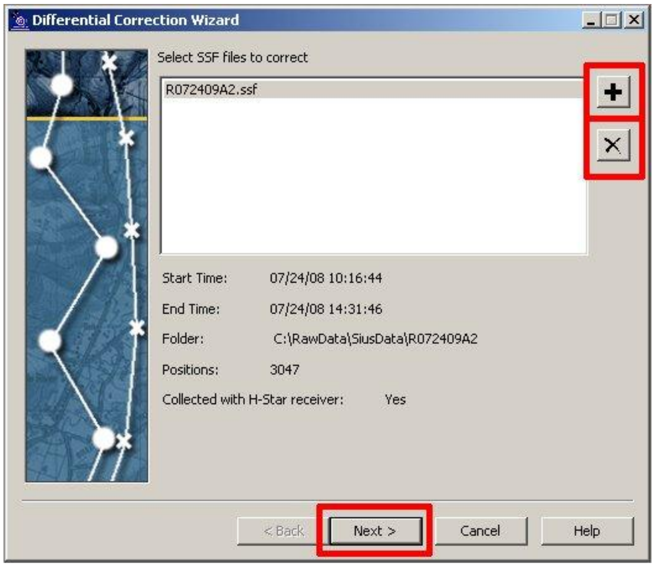
**f.** The *Transfer Completed* dialog appears. This dialog will tell you if the transfer(s) was/were successful. You should check on the location of the transferred files by clicking *More Details…*to access the log file and looking at each file path. The files should be transferred to the same directory as the raw data files. The format is converted to SSF (extension .ssf). There is a backup of the SSF file saved to the *Backup* folder in the project folder by default. Click *Close* when satisfied. Click *Close* to close the *Data Transfer* window.

**4.** View the data to ensure that it is what you want.

**a.** From the main menu, go to *View*-> *Map*. If necessary, select the SSF file(s) that you just created-> click *OK*.

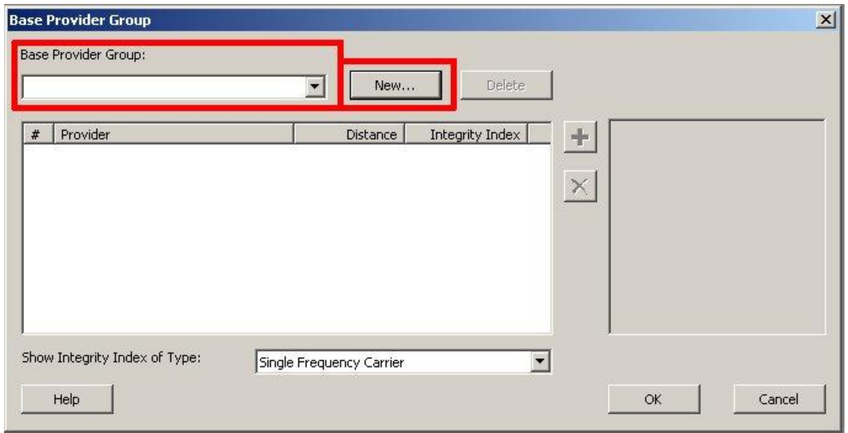
## Differential Correction

1. With the same project folder open as above, got to *Utilities-> Differential Correction….*
2. The *Differential Correction* wizard appears.

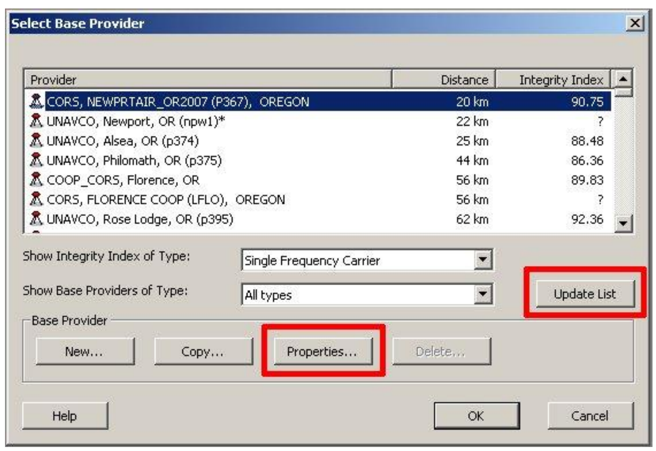



   a. If the correct files do not appear in the *Select SSF files to correct* field, click the plus sign-> navigate to and select the relevant files-> click *Open*. Remove any incorrect files. Click *Next* when finished.
      i. Below the *Select SSF files for correction* window, there is some information about the file, including whether or not the file was collected using an H-Star GPS receiver.
   b. If the data was collected with an H-Star receiver, select *Automatic H-Star Carrier and Code Processing*. If the data was not collected with an H-Star receiver, select *Automatic Standard Carrier and Code Processing*. Click *Next*.
   c. The settings on the next screen can be adjusted by clicking the *Change* button. Accept the defaults by clicking *Next*.
   d. Click *Select* next to the *Base Provider Group* field.
      i. If you have an appropriate group already, select it from the *Base Provider Group* drop-down menu, check to make sure the selected base station is still the best option (plus sign-> *Update List*), and skip ahead to (iii). If you do not

already have an appropriate group, click *New…* next to the *Base Provider Group* drop-down menu. Name it something obvious-> click *OK*.




**ii.** Click the plus sign. A list of base stations appears, with their distance from the data and an integrity index (higher is better).




– Click the *Update List* button to acquire the latest list. The *Downloading base providers…* window appears while the download is taking place.

– Select a nearby base station, with a relatively high integrity index and a bias towards CORS stations.

– Click *OK* to exit the *Select Base Provider* window.

**iii.** Click *OK* to exit the *Base Provider Group* window.

**e.** Select *Use reference position from base providers* in the *Reference Position* section of the window. Check the box next to *Confirm base data and position before processing*. Click *Next*.

**f.** Select where you want the new corrected data file (extension .cor) to be saved and how you want it to be named. Click *Start*.

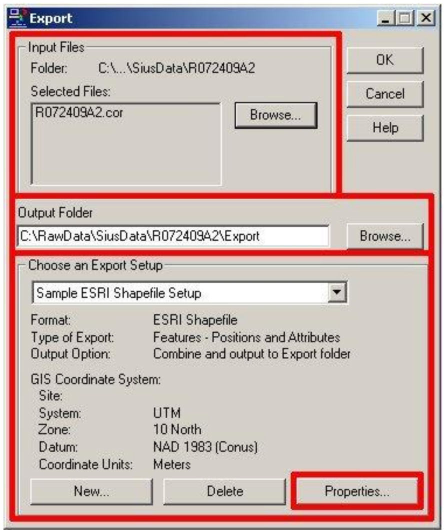
    i. If the process stalls, click Close and start again from step 1.
    ii. Click *Confirm* when required.
  g. When the process is complete, the window will say "Differential correction complete." You should look at the data in the window to confirm that the correction was successful.
    i. Useful data includes the number of positions corrected, the number uncorrected, which method (carrier or code) was used for how many positions, how many positions were thrown out, and estimated accuracies for the data.
    ii. When finished, click *Close*.

3. Check to ensure that the corrected file contains the same data as the uncorrected file.
  a. From the Pathfinder Office main menu, go to *File*-> *Open…*. Navigate to the uncorrected SSF file (extension .ssf) and click *Open*.
  b. If the map viewer is not already open, go to the main menu-> *View*-> *Map*. Drag the corners of the map until it is as large as possible. Right-click anywhere on the map without data-> *Zoom To Extents*.
  c. On your keyboard, press the *Print Screen* button (may say *Print Scrn*, etc.).
  d. Paste the screen print into a new document in a word processor, such as Microsoft Word or OpenOffice (which is open source and free).
  e. Repeat, but open the corrected COR (extension .cor) file, and use the same word processor document. You may have to resize one or both of the images to get them to both fit on a page.
  f. You can compare the SSF and COR either on the screen, or you can print the page out.
  g. If there are one or more road sections missing from the corrected file, you will have to re-correct the SSF file, starting at step 1. This time, use a different base station.

## Exporting as Shapefiles

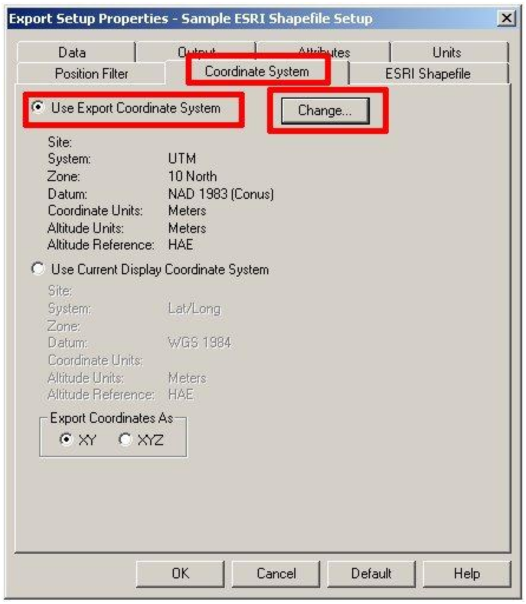
The new exported shapefiles are saved to the Export folder in the project folder. All of the possible shapefiles are BBASE_DI, END_RD, DIFF_DRA, DTCH_REL, GATE, GULLY, LANDSLID, LEAD_OFF, NON_ENGI, PHOTO, Point_ge, REVISIT, ROAD, ROAD_CLS, ROAD_HZR, STRM_CRO, SUMP, and WATER_BA.

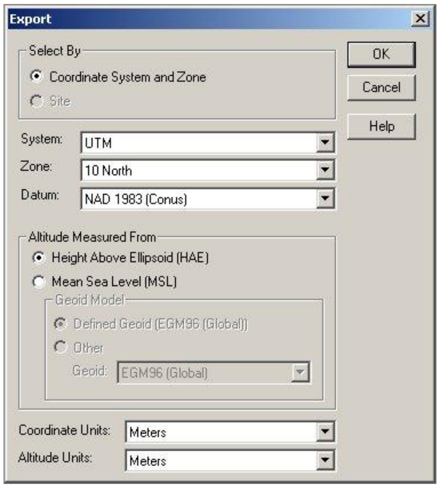
1. With the same project folder open as before, go to the main menu-> *Utilities*-> *Export….*
2. The *Export* window appears.




   a. In the *Input Files* section, click *Browse...*-> navigate to the location of the differentially corrected file or files that you wish to export to shapefiles-> select the necessary COR files-> click *Open*.
   b. You can change the location of the output folder by clicking *Browse…* next to the *Output Folder* field.
   c. In the *Choose an Export Setup* section of the window, choose *Sample ESRI Shapefile Setup* from the drop-down menu.
   d. Check the coordinate system in the area under *GIS Coordinate System* to make sure it is correct. If using UTM, make sure the zone is set correctly.
      i. If the coordinate system is not correct, click *Properties…*-> click the *Coordinate System* tab-> select *Use Export Coordinate System*-> click *Change…*

– Use the drop down menus to select the appropriate coordinate system and associated properties-> click *OK*.




**ii.** You can change other export properties in the *Properties* window if you desire. Click *OK* to exit the *Properties* window.

**e.** Click *OK* to export the file or files.

**f.** The *Export Completed* window appears when the export is complete. This window shows how many features were in the initial COR file(s), and how many features were exported. You want there to be the same number of features originally as after export. You can click *More Details…* to see exactly which files were created and where they are located, similar to the log file created for the data transfer process. This text file is saved to the same folder as the exported files. Click *Close* when you are finished viewing the *Export Completed* dialog.

**3.** Each shapefile is composed of a number of files that are readable by ArcGIS. Use ArcCatalog to move or copy the shapefiles into the appropriate GIS workspace. Pre-processing can now begin.

# SECTION II: PREPROCESSING

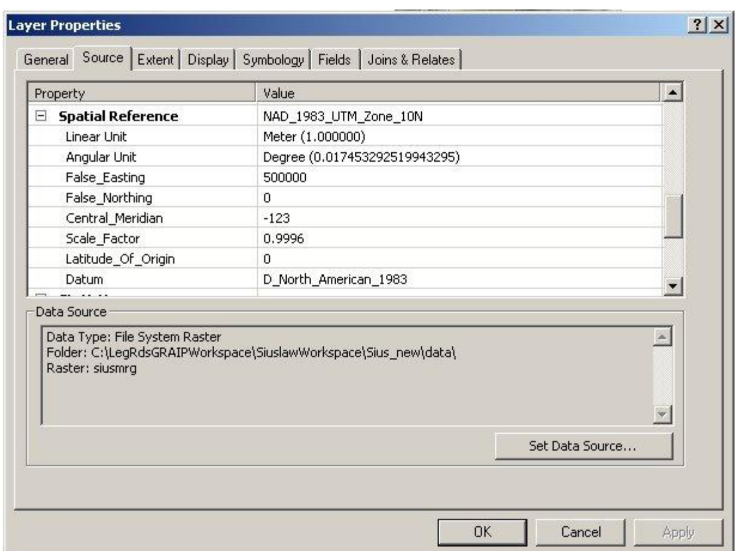
This section lists the steps that must be completed using ArcMap and the GRAIP Preprocessor before the analysis steps can begin, but after the Pathfinder Office steps are complete. The DEM must be clipped to the appropriate watershed, and the shapefiles must be pre-processed. Any errors within the data must be corrected, and the road lines must be straightened.

## Clipping the DEM

**1.** Open ArcMap and add the DEM and the HUCs.

**2.** Make sure the HUCs and the DEM are in the same projection. It's good to make copies of both with ArcCatalog before changing their attributes.

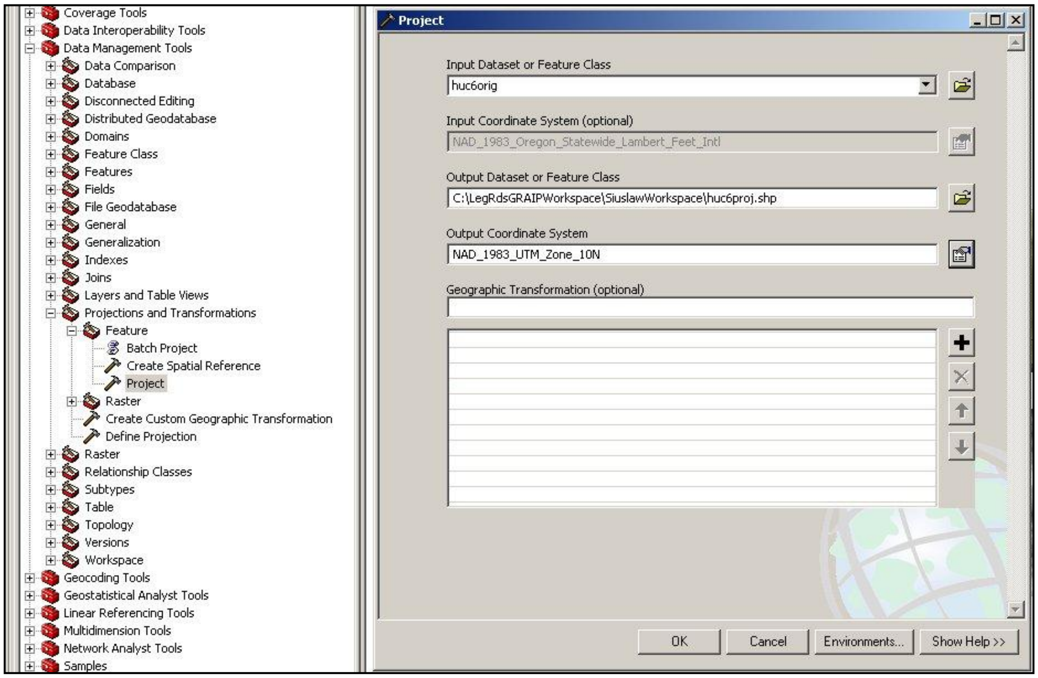
  **a.** Open the *Layer Properties* window for each layer-> *Source* tab-> scroll down to *Spatial Reference*. If the two layers have the same *Spatial Reference*, move on to step 3. If they do not, or if one is undefined, proceed, even if both layers are overlapping as they should.




**3.** If the DEM is in the wrong projection, re-obtain it in the correct projection. If the HUCs are in the wrong projection, they should be projected or re-projected to the same coordinate system as the DEM.

  **a.** Open ArcToolbox-> *Data Management*-> *Projections and transformations*-> *Feature*-> *Project*.

**i.** From the *Project* window:




- Under *Input Dataset or Feature Class*, select the HUCs shapefile.
- If there is nothing under *Input Coordinate System (optional)*, select the projection that you think the HUCs are in.
- Under *Output Dataset or Feature Class*, select the folder in which you wish to save the new projected HUC shapefile (probably the same place as the original HUCs), and type a new name for the new HUCs.
- Under *Output Coordinate System*, import the coordinante system for the DEM
- Click *OK*. A new shapefile that contains the HUCs and is projected the same as the DEM is created. Use this HUC layer for the rest of the steps.

**b.** The projected HUCs and DEM should be overlapping properly in the ArcMap viewer screen.

**4.** Choose which HUCs you need.

**a.** Add all of the roads you will be analyzing to ArcMap, overtop of the HUCs (which should be overtop of the DEM). If the roads are mis-registered, re-project them as you did for the HUCs above.

**b.** Set the transparency of the HUCs layer to 35%. This is useful when determining the extents of each watershed and associated flow paths.

**i.** From the *Layer Properties* for the HUCs-> *Display*-> type 35 in the *Transparent* box.

**c.** The HUCs you want are those that encompass the roads, their sub-watersheds, and all surface flow paths that water intercepting those roads could take, until all of those flow paths are in common with one another.

**5.** Delete the rest of the HUCs.

**a.** *Start editing* in the *Editor* toolbar-> choose the folder with the HUCs if prompted.

**b.** Use the *Edit tool* from the *Editor* to select all of the HUCs you don't need. ArcMap Main Menu-> *Edit*-> *Delete* to delete those.

**c.** *Editor*-> *Save edits*.

**6.** Merge all of the HUCs into one. This is necessary for the buffering step (7).

**a.** Select all the remaining HUCs at once.

**b.** *Editor* toolbar-> *Target*-> HUCs layer.

**c.** *Editor*-> *Merge*-> any option will do-> click *OK*.

**d.** Save the edits.

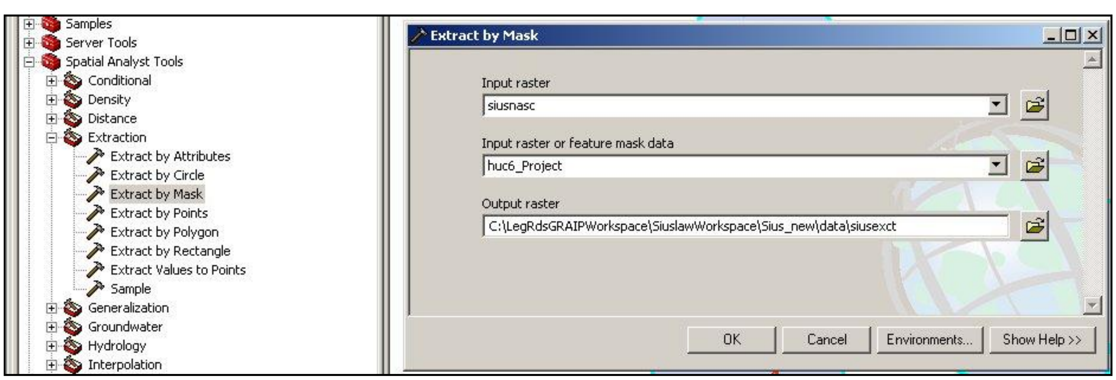
**7.** Buffer the new single HUC.

**a.** Use the *Edit Tool* from the *Editor* toolbar to select the single HUC feature.

**b.** *Editor*-> *Buffer*…-> enter 500 m, or rough equivalent-> hit Enter key.

**8.** Extract the DEM. This final step results in a new DEM that is the shape of the buffered HUC, ready to be processed in GRAIP.

**a.** ArcToolbox-> *Spatial Analyst*-> *Extraction*-> *Extract by Mask*. Enter the DEM as *Input Raster*, the now merged and buffered HUC layer as *Input raster or feature mask data*, and an appropriate location and name for the new extracted DEM (probably the same folder as the original DEM; any eight-character or fewer name will do, but it should be clear which is the extracted DEM). Click *Compute*.



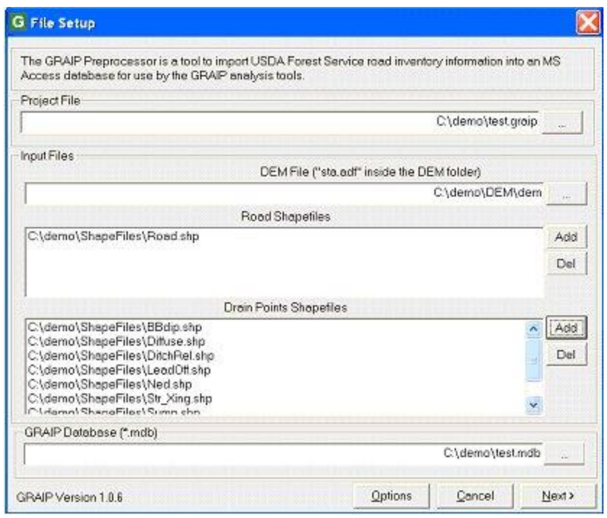
## Using the GRAIP Preprocessor

In total, eight files are created, not including the multiple files that make up the shapefiles (FileName.graip, DrainPoints.shp, RoadLines.shp, FileNameDP.log, FileNameRD.log, FileName.mdb, FileNameshpdp.txt, and FileNameshprd.txt).

**1.** In the GRAIP Preprocessor, create a new .graip file

   **a.** Under *Project File*, navigate to the folder with your shapefiles or wherever you want to save the .graip and other created files. Name the file with something relevant. Do not use spaces.

   **b.** FileName is used here to refer to the .graip, etc.




**2.** Select the DEM

   **a.** Under *DEM File*, select the desired clipped DEM, referred to here as just "dem" (it should be in the same folder in which you intend to save the TauDEM-created files). Double-click dem, and select sta.adf.

   **b.** If you don't have the DEM, you can still correct errors. For this step, use a dummy DEM (any DEM). You will have to re-preprocess the data with the correct DEM before running GRAIP.

**3.** Add the road shapefile(s), and the drain point shapefiles.

   **a.** Under *Road Shapefiles*, navigate to the location of the ROAD shapefile(s), and select them.

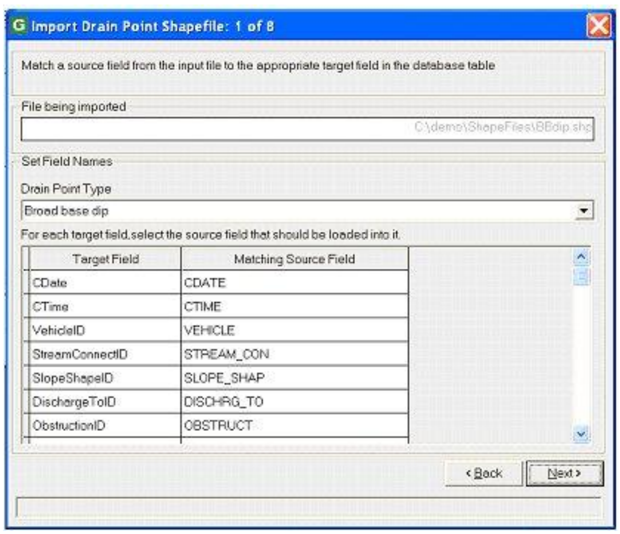
   **b.** Under *Drain Points Shapefiles*, navigate to the location of the drain point shapefiles, and select them. There are eight possible drain point shapefiles, but not every study will have them all. They are BBASE_DI, DIFF_DRA, DTCH_REL, LEAD_OFF, NON_ENGI, STRM_CRO, SUMP, and WATER_BA.

**c.** You can add more than one shapefile with the same name. In this case, the other set(s) of shapefiles should be in a separate folder or folders in the same location as the rest of the shapefiles.

**4.** Under *Options*, ensure *Step by step* and *Manual resolution of invalid/missing data values* are selected in the *Processing* field.

**5.** Click *Next*. At this point, all of the files that are created by the preprocessor have been created, except DrainPoints.shp and RoadLines.shp. The next steps import the drain points and road shapefiles.

**6.** Check to make sure all of the *Target* and *Source* fields match up properly. If you have the latest version of GRAIP and the latest data dictionary in the field, they should match. When you are sure everything matches, click *Next*. Repeat this process for all drain points.




**a.** The road lines are similar.

**b.** If a property exists in the data dictionary in the field, but not in GRAIP, the *Define Value* dialog appears.

**i.** You have three options, *Use default value, Reassign this value in definitions table,* and *Add new entry to definitions table*. Select the appropriate choice. Generally, *Add new entry to the definitions table* is most appropriate.

**7.** Preprocessing is now complete. The FileNameDP.log and FileNameRD.log files, located in the same folder as FileName.graip, contain the errors that the preprocessor found, used in the next step.

**8.** In the next step, you will locate and fix any errors. When you re-preprocess the data, after the errors are corrected, and any time the DEM used does not change (including if you change which shapefiles are used, so long as the DEM remains the same), you can just select the already created *Project File* (FileName.graip) on the first screen. Click *OK* when asked if you want to delete the DrainPoints, RoadLines, and FileName.mdb files. Proceed as before. If you change the DEM, you must use a new .graip (e.g. FileName2.graip). Again, click *OK* when asked if you want to delete the DrainPoints, RoadLines, and FileName.mdb files. If no points have been added or deleted from the original shapefiles, the preprocessor assigns the same GRAIPDID/GRAIPRID number to each point as it did the first time.

## Editing Data Errors

An error is logged for a drain point if its CTime/CDate/VehicleID combination is not referenced to any road segment. An error is logged for a road line segment if *none* of the entered CTime/CDate/VehicleID combinations correspond to a drain point.

The fundamental goal of error checking is to ensure that each flow path on each road segment drains to the appropriate and valid drain point. The ROAD and the various *original* drain points shapefiles must be edited. The shapefiles generated by the GRAIP Preprocessor (DrainPoints.shp and RoadLines.shp) are *not* edited.

CTimes in the ROAD layer are in 24-hour format, rounded to the nearest minute, and without colons (so, 1537 means 03:37:25, 03:36:48, 03:37:30 etc.). xx:xx:30 rounds down, and xx:xx:31 rounds up. The CTimes in the original drain point are in 12-hour format, with seconds. The CTimes in the original drain point must be in the format xx:xx:xx, or GRAIP won't know what the CTime means.

**1.** Print the error log files (FileNameDP.log and FileNameRD.log) for easier reference (they can be combined into one page).

**2.** Add the original shapefiles (ROAD, DIFF_DRA, etc.) to ArcMap. Also add the RoadLines and DrainPoints shapefiles generated by the GRAIP Preprocessor and the PHOTO shapefile for reference. Arrange the RoadLines and DrainPoints layers under the rest of the layers in the *Table of Contents* window.

- **a.** Label the RoadLines and DrainPoints layers for easier reference.

**3.** Open the attribute table for the DrainPoints. The GRAIPDID and FID columns correspond to the "GRAIPDID" column in the error log. This also applies to the RoadLines attribute table and error log.

**4.** For each point in the drain points error log, find the corresponding point in the Attribute Table (same GRAIPDID number).

- **a.** Find the GRAIPDID number on the error log in the Attribute Table and select that point. Zoom in on the selected point.
- **b.** Use the *Identify* tool from the ArcMap Tools toolbar to select the drain point from the original shapefile (e.g. SUMP) that directly overlays the selected (and labeled) point from the DrainPoints layer.
  - **i.** Since the point from the DrainPoints layer is directly underneath the point from the original shapefile, and the *Identify* tool selects the top-most layer by

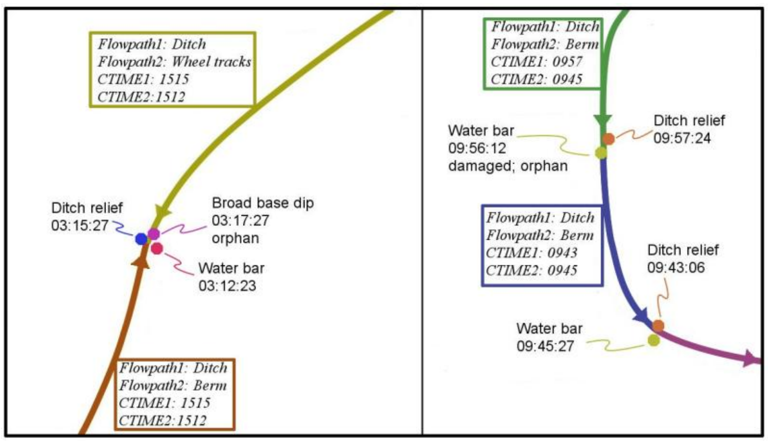
default, the original shapefile is selected. This also applies to the RoadLines and its corresponding original shapefile (ROAD).

**5.** Now you must decide which type of error is occurring at this point and how to fix it.

**a.** If the comment in the *Identify* box says "orphan," this is most likely an intentionally orphaned point. Note this on the error log hard copy, and move on to the next point.

**b.** Note the *CTIME* in the *Identify* box of the original drain point shapefile. Use the *Identify* tool in the same way to look at the surrounding road segments (in the original shapefile; ROAD). Remember that each road segment has two flow paths.

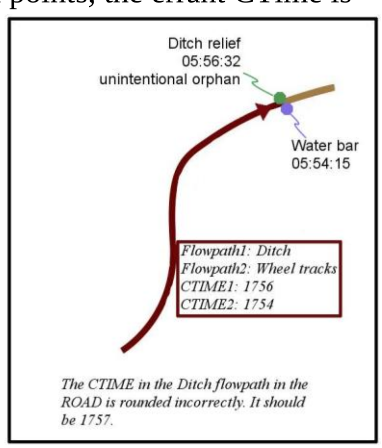
**i.** If the drain point error is most likely an unlabeled intentional orphan, label it as such in the Attribute Table for that drain point.




– Look in the *Identify* box of the drain point in question and note its *FID*. Open the attribute table for that drain point type, scroll to the FID. In the *COMMENT* field of the drain point, type "orphan."

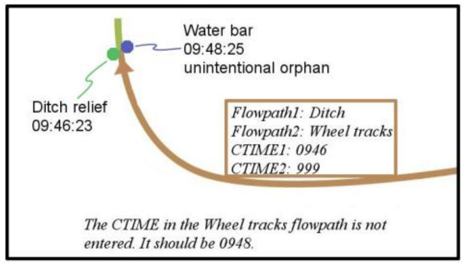
**ii.** If both surrounding road segments have CTimes in all used flow paths, but not all CTimes are accounted for in nearby drain points, the errant CTime is probably supposed to be the CTime from the problem drain point.

– Enter the correctly rounded CTime from the drain point into the cell with the incorrectly rounded CTime in the ROAD attribute table.




*The CTIME in the Ditch flowpath in the ROAD is rounded incorrectly. It should be 1757.*

**iii.** If both surrounding road segments do not have CTimes in all used flow paths, the problem drain point is probably the missing CTime in the ROAD. Check to see that the drain point type makes sense with the flow path.

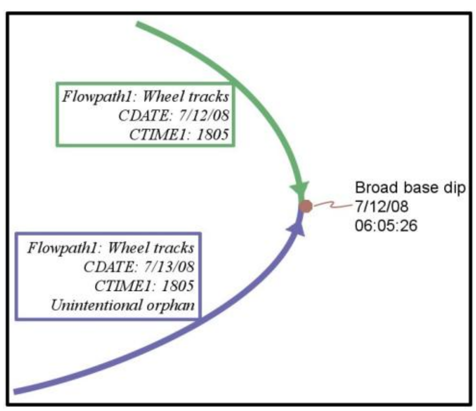



– Enter the correct CTime into the ROAD table.

– If some other drain point appears to be the missing CTime from the road line, enter it in the missing place in ROAD. The errant drain point may be an intentional orphan.

**c.** Some other errors include those in CDate and VehicleID.

**i.** CDate errors can occur when a drain point from one day is referenced the next day. Change the CDate in either the road segment or the drain point, whichever is easier. This can get messy if more than one road segment drains to that point, or the road segment has two flow paths, because all drain points associated with the road segment must have the same CTime/CDate/VehicleID combination.




**ii.** VehicleID errors can happen if two crews collected a point at the same time on the same day, but one of the crews accidentally entered the VehicleID of the other crew.

**d.** The last kind of error will present itself as a drain point or road line with all default properties, as a drain point of the same type, in the same location, and with the same properties as another (except CTime/CDate/VehicleID, which are automatically generated), or as a road line in the same place and with the same properties as another. There is a possibility that this is intentional, but duplicates should be deleted in any case.

**i.** Delete duplicate or unintentional drain points. Use the *Edit Tool* from the to select the erroneous point or line, being sure that you have selected the correct point or line, and then, from the Main Menu-> *Edit*-> *Delete*.

**ii.** Be sure to correct any further errors generated by deleting duplicate points, as above.

**6.** Repeat the above steps for the rest of the errors in the log, noting in the error log hard copy what has been done to fix the problem (or if the point is an intentional orphan), and saving the edits.

**7.** Repeat the above steps 3-6 for the ROAD and RoadLines layer.

**8.** When all errors in the error logs have been addressed, save the edits, and then stop editing. Open a new map file.

**9.** Re-run the GRAIP Preprocessor, as described above. Look at the new error logs to verify that the only errors generated for the drain points are intentional orphans (if any). There should not be any errors in the road lines error log, because road line errors are only generated when the road segment has no associated drain points, which cannot happen on the ground.

## Straightening Road Lines

The most important thing when straightening road lines is that they are consistent. A good guideline for editing road lines is to try to create smoothly curving segments that have a high frequency amplitude of less than six meters. Remember that roads are generally smoothly changing features.

**1.** Add all original road lines and drain points (ROAD, SUMP, etc.). If you have a previous version of the road that has already been corrected (as in pre-and post-treatment for the Legacy Roads project), add it as well.

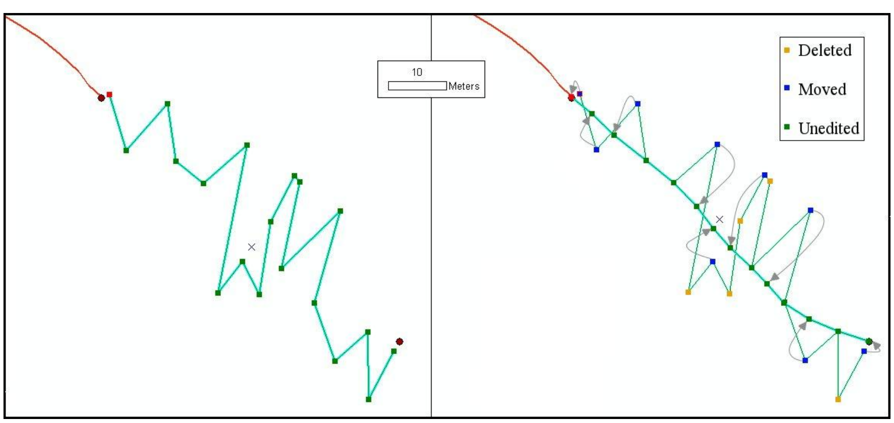
**2.** Start editing. Zoom in on the end of a road (1:500 or so is a good scale for this level of editing). If there is zigzag that is composed of only a few points, you can delete or move those points until the road line is straight again. If there is a rat's nest at the end of a line, or if there is zigzag composed of a lot of points, you can use the *Split* tool to divide the line in two and delete the bad part. See steps 3 to 5 below.

- **a.** Use the drain pointa to connect one road line to another.
- **b.** The ends of the road lines should be right on top of the drain point, as viewed at the above scale. All drain points should be at the end of the road line, except some orphans and diffuse drain points, which may or may not be at the end of the line.

**3.** To delete individual vertices:

- **a.** Using the *Edit Tool*, double-click the road line to display its vertices.
- **b.** Right-click an errant vertex. Select *Delete Vertex.*
- **c.** You can also insert a vertex on a line from the same menu.

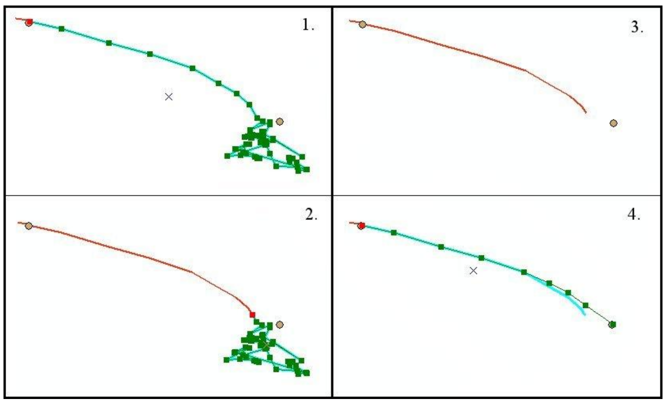
**4.** To move a vertex, move the *Edit Tool* over the vertex that needs to be moved. Click and drag it to its new location.



**5.** To use the *Split Tool* to delete a rat's nest or portion of very bad line:

**a.** Select the line with the *Edit Tool.* Using the *Split Tool*, click on the line to one side of the rat's nest or portion of very bad line. You have now divided the single line with a certain set of properties and a certain FID number in the Attribute Table into two lines with the exact same properties. One line retains the original FID number, and the other line is assigned a new number.

**b.** Use the *Edit Tool* to select and delete the rat's nest or portion of very bad line. You can either go to the ArcMap Main Menu-> *Edit*-> *Delete*, or use the Delete key on the keyboard.




**c.** If the road line is very bad, and there is a high frequency of vertices, it may be easier to split the road line in two, delete the worse section, and re-construct the entire line from the remaining points.

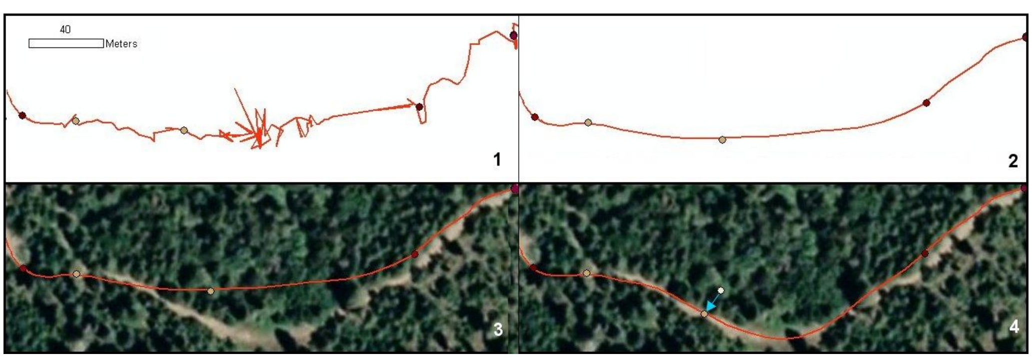
**d.** After a section of road is deleted, you must re-construct that portion of the line.

**e.** In order to make sure you haven't deleted anything that shouldn't have been deleted, or left something that should have been deleted, check the Attribute Table for the ROADS layer before you begin, and note how many table entries there are (in the bottom-middle of the table window, *Records (*blank *out of total Selected).*

**6.** Add a background aerial photo now.

**a.** If you have a 1 m resolution image, 1:1600 or so is a good scale.

**7.** Check to make sure the road on the photo is registered the same as the road line from



the data.

8. Check to make sure the road line from the data follows the road on the photo, and is contained within the width of the road on the photo.
9. Check the number of entries in the ROAD Attribute Table, as described in step 5 above.
10. When finished, save the edits, stop editing and open a new map file.
11. Re-run the GRAIP Preprocessor, as described above. This will generate RoadLines and DrainPoints shapefiles that reflect the changes made to the road lines.
    a. It is a good idea to look at the error logs once more to ensure nothing has changed.

# SECTION III: RUNNING THE GRAIP MODEL

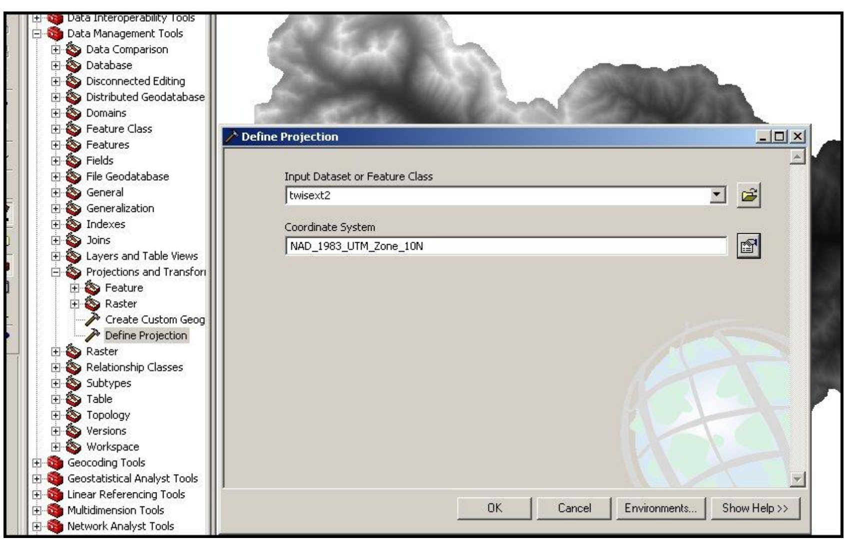
This section describes the steps that are taken to run the actual GRAIP model with the GRAIP toolbar. TauDEM must first be run to generate files to be used by GRAIP. There are some initial steps that must be taken in the GRAIP toolbar and Hawth's Tools before true analysis can begin. There are three main parts of the GRAIP process that must be competed in order. SINMAP is used to generate files that are used in the middle step of the GRAIP process.

## Running TauDEM

There are 13 grid files created by TauDEM (dem stands for the name of the DEM used): demfel, demsd8, demp, demang, demslp, demad8, demsca, demgord, demplen, demtlen, demsrc, demord, and demw. There are two shapefiles created by TauDEM: demnet, demw. The stream network shapefile (demnet) is associated with FileName.graip, and is added when the .graip is opened.

**1.** The projection for the clipped (to the HUC boundary) DEM must be defined if it is not already.

**a.** In ArcToolbox, go to *Data Management-> Projections and Transformations-> Define Projection*.




**i.** Under the *Input Dataset or Feature Class*, select the DEM.

**ii.** Under the *Coordinate System* field, navigate to the projection that the DEM is in, click *Add*, then *Apply* and *OK*.

**iii.** Click *OK*. The projection is now defined.

b. Close ArcMap or open a new map file. This will set the ArcMap viewer with the correct projection information before TauDEM is run.

2. If you don't have one already, create an ArcInfo workspace for the TauDEM (and later SINMAP) files with ArcCatalog. Put a copy of the DEM in the workspace.

   a. Close ArcCatalog or navigate away from the new workspace. TauDEM and ArcGIS might get confused if the workspace they are modifying is active (currently being viewed) in ArcCatalog at the same time.

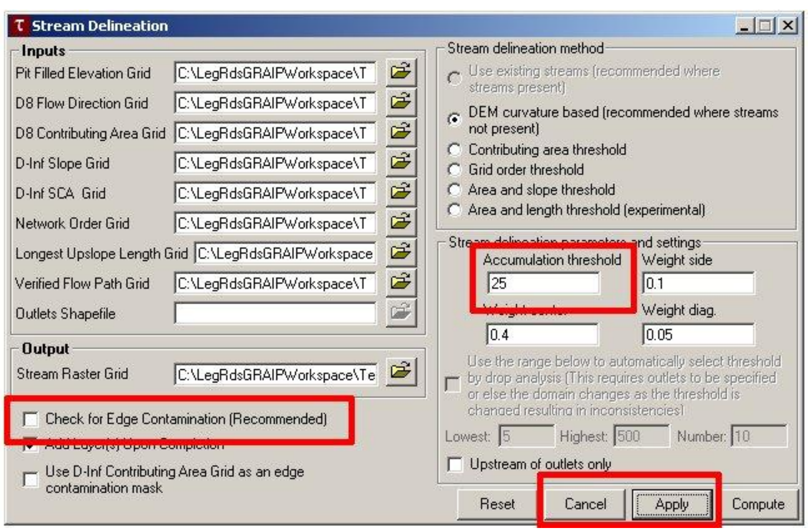
3. Open ArcMap and add the clipped DEM with the projection defined from the TauDEM workspace to the viewer.

4. It is best to do the rest of these steps one immediately after another. From the TauDEM toolbar-> *Basic Grid Analysis*-> *Select Base DEM grid…*

   a. Use the drop-down menu to select the DEM.

5. Go to *Basic Grid Analysis*-> *Full River Network Raster*. You don't want to run this step now, just adjust its parameters.

   a. Uncheck *Check for Edge Contamination*




      i. This will automatically uncheck *Use D-Inf Contributing Area Grid as an edge contamination mask.*

   b. Change the *Threshold* to 25

   c. Click *Apply* twice (to ensure it registers), then *Cancel*.

6. Go to *Basic Grid Analysis*-> *Do All*.

   a. Double-check the default parameters and click *Compute*.

  - **b.** This step produces 11 grids (demfel, demsd8, demp, demang, demslp, demad8, demsca, demgord, demplen, demlen, demsrc).

**7.** Go to *Network Delineation-> Do All Network and Watershed Delineation Steps*.

  - **a.** Click *OK* when asked if it's OK to delete the existing src output file.
  - **b.** This step creates the last four grids and shapefiles (demord, demw, demnet.shp, demw.shp).
  - **c.** Do not use an outlet point.

**8.** Before proceeding, close ArcMap or open a new map file.

# The Preprocessor Menu

**The first method, for when you plan to do a complete GRAIP study, is as follows:**

**1.** Open the .graip file with the GRAIP toolbar.

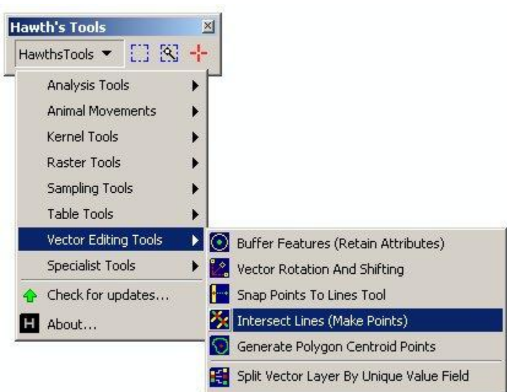
**a.** GRAIP toolbar-> *File*-> *Open*-> navigate to the location of the .graip and select it-> click *OK*. DrainPoints, RoadLines, demnet, and the DEM will be added to the map.

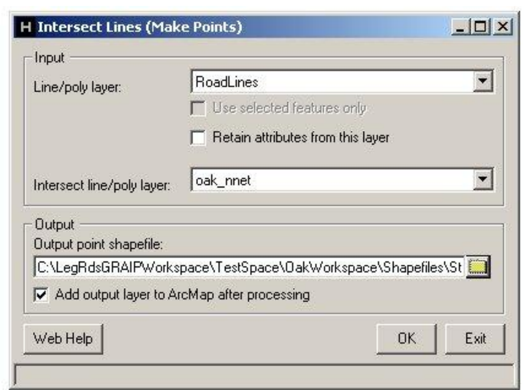
**2.** GRAIP toolbar-> *Preprocessor*-> *Extract Stream Crossings*.

**a.** Under *Input*, ensure the proper DrainPoints shapefile is selected.

**b.** Under *Output* ensure the new shapefile will be saved to the correct place (which should be the same place as the rest of the shapefiles, including DrainPoints, etc.) and is correctly named (should be StrXingEx).

**3.** Hawth's Tools toolbar-> *HawthsTools* menu-> *Vector Editing Tools*-> *Intersect Lines (make points)*.






**a.** For *Line/poly layer*, use the drop down to select the RoadLines layer.

**b.** For *Intersect line/poly layer*, select the demnet layer.

**c.** For *Output*, save the new shapefile to the same location as the extracted stream crossings, and name the file "StrXingRi."

**d.** The new shapefile is composed of the points at which the road intersects the stream network.

**4.** Hawth's Tools toolbar-> *HawthsTools* menu-> *Vector Editing Tools*-> *Snap Points to Lines Tool*.

a. Under *Point feature layer*, select the extracted stream crossings layer (StrXingEx).

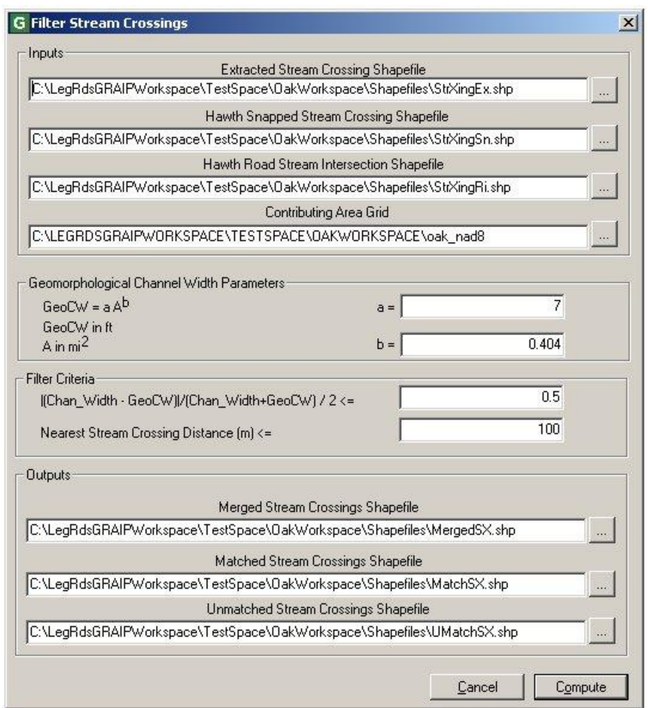
b. Under *Line or polygon feature layer*, select the stream network shapefile (demnet).

c. Under *Output*, save the file as "StrXingSn" in the same place as the other two recently created shapefiles.

d. The new shapefile is not added to ArcMap, so add it in the normal fashion.

e. There is a known problem with this step that occurs sometimes. The first time you attempt to create this shapefile, the tool crashes. The solution is usually to close ArcMap (no need to save anything), use ArcCatalog to delete the already created, but in error, StrXingSn shapefile, and restart ArcMap. Add the extracted and intersected shapefiles, and re-do this step.

**5.** GRAIP Toolbar-> *Preprocessor-> Filter Stream Crossings*.

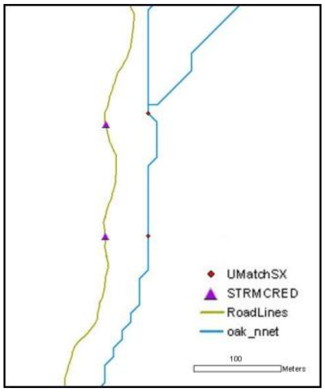



a. There are a series of parameters that can be changed in this window. It is not generally necessary to do that.

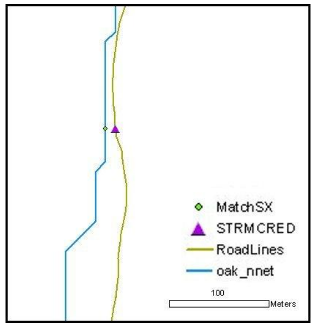
b. Further discussion of this step can be found in Appendix B of the full length Office Manual and in Prasad 2007.

**c.** Ensure that the inputs are correctly located. The *Contributing Area Grid* is demad8, which was produced by TauDEM.

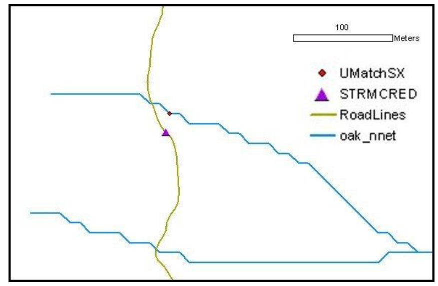
**d.** Ensure that the three outputs are correctly located (with the rest of the shapefiles) and named (“MergedSX,” “MatchSX,” and “UMatchSX”).




**These two observed stream crossings (STRMCRED) are on small side streams that do not show up in the TauDEM stream network shapefile. Their channel width is much smaller than the channel width of the main channel, so the snapped points show up as UMatchSX points**.




**This is a case where the observed stream crossing (STRMCRED) is on a small side stream that does not show up in the TauDEM stream network shapefile, and the nearby main channel has a similar width. There is no real stream crossing on the main channel here, and so the MatchSX point is incorrect.**




**In this example, the observed stream width is different from the calculated width. The UMatchSX point should be a MatchSX point, because there is really a stream crossing at this location.**

**6.** Now you must check to make sure the MatchSX and UMatchSX shapefiles are correct. The end result of the *Filter Stream Crossings* and *Create TauDEM Stream Network* functions is a new stream network shapefile (demnet) that is split at its road-stream intersections, and a shapefile that contains the stream crossings at those intersections (this is MatchSX). During the *Filter Stream Crossings* step, three shapefiles are generated, MatchSX, MergedSX, and UMatchSX. In the end, UMatchSX will basically contain surveyed stream crossings that are not on the demnet stream network and MatchSX will contain those surveyed stream crossings that are on the demnet stream network.

**a.** If any UMatchSX points are not OK, you will have to edit the original STRM_CRO shapefile, re-run the GRAIP Preprocessor, and re-run the GRAIP steps to this point (extract, intersect, snap, and filter the stream crossings). The idea is to fool the *Filter Stream Crossings* tool into thinking that all filter criteria are met.

**b.** Use ArcCatalog to make a copy of the original STRM_CRO shapefile (don't edit the original!; call it something like STRMCRED). Add the STRMCRED layer to the ArcMap file with the rest of the shapefiles and data added and generated so far.

**c.** For each UMatchSX point, find out why it didn't pass.

**i.** The *Note* field of the *Identify* window of the UMatchSX point will say either "Fails automated distance criteria," or "Fails Channel Width Criteria". For the former, nothing should be wrong, but check to make sure that the observed crossing is not supposed to be on a demnet stream anyway.

**ii.** If the channel width criteria are the problem, find the corresponding observed stream crossing on the map from the STRMCRED layer. Note the location of the observed crossing and the location of the UMatchSX point. If the UMatchSX point is correct (i.e. the observed stream crossing—STRMCRED—is not located on the same stream as the UMatchSX point), move on to the next point. If the UMatchSX point is incorrect (i.e. the observed stream crossing is located at the same place on the same stream as the UMatchSX point, but the observed and calculated stream widths are too different), proceed to the next step.

**d.** In the *Identify* box of the UMatchSX point, note the observed channel width (*CHAN_WDTH*) and the calculated channel width (in the *GeoCW* field). The two numbers should not be close (more than 1 or 2 ft apart). Change the *CHAN_WDTH* field of the observed point in the STRMCRED layer to match the *GeoCW* field from the *Identify* box of the UMatchSX point (round to the nearest integer).

**i.** Start editing.

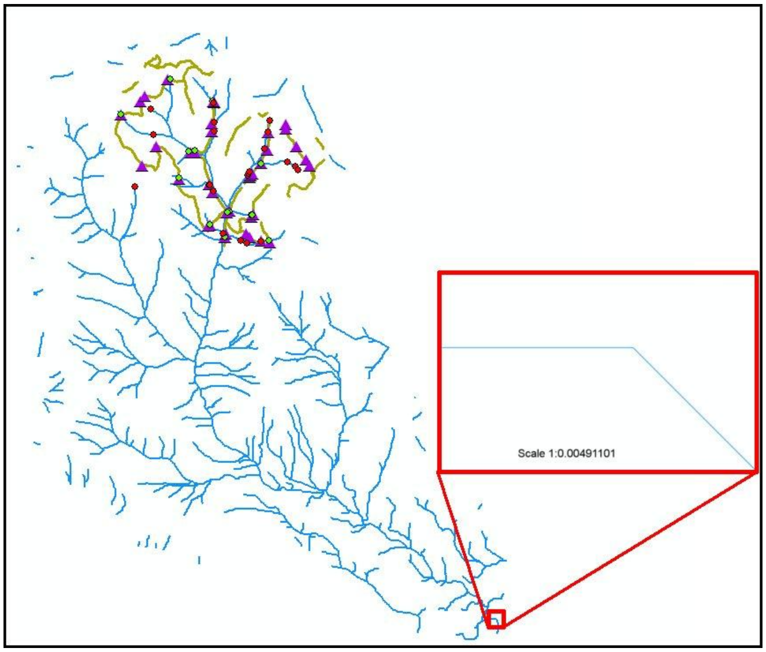
**ii.** In the STRMCRED Attribute Table, scroll to the entry for the *FID* number from the STRMCRED point's *Identify* box. Type in the rounded *GeoCW* number from the UMatchSX point in the *CHAN_WDTH* field of that FID number.

**iii.** *Editor-> Save Edits*.

- **e.** Repeat steps e. and f. for all other incorrect UMatchSX points. Check all MatchSX points, repeating the same process, but changing the *CHAN_WDTH* to be dissimilar to the *GeoCW* from the MatchSX *Identify* box (usually, more than 2 ft of difference is enough).
- **f.** Save the edits and stop editing. Open a new map window.
- **g.** Run the GRAIP Preprocessor, replacing the STRM_CRO layer with the edited STRMCRED layer.
- **h.** Open the new GRAIP file (the .graip) in ArcMap. Repeat the *Extract Stream Crossings*, Hawth's *Intersect Lines (make points)*, Hawth's *Snap Points To Lines*, and *Filter Stream Crossings* steps. Check to make sure your edits worked, and recheck to make sure there are no further UMatchSX or MatchSX problems.

**7.** Now you must create an outlet file for the *Create TauDEM Stream Network* step to use.

- **a.** Use ArcCatalog to create a new shapefile called "Outlets" in the workspace with the rest of your shapefiles.
  - **i.** Right-click in the shapefiles folder-> *New*-> *Shapefile…*
  - **ii.** Name it "Outlets," and select *Point* as *Feature Type*.
- **b.** Open the GRAIP file (the .graip) in ArcMap. Add the MatchSX and Outlets shapefiles.
- **c.** Start editing and select the folder with the Outlets shapefile. Set the *Target* to the Outlets layer.
- **d.** Open the Attribute Table for the MatchSX layer. Click -> *Select All*. From the ArcMap Main Menu-> *Edit*-> *Copy*. Close the Attribute Table.
- **e.** Open the Attribute Table for the Outlets layer. From the ArcMap Main Menu-> *Edit*-> *Paste*. Save the edits. Notice that there are now Outlets points everywhere that there are MatchSX points.
- **f.** Zoom in as close as possible on a point on the main stream, downstream from all of the roads. This should be pretty far downstream.
  - **i.** Use the *Sketch Tool* to create a point directly over the stream network line.
- **g.** Save the edits and stop editing. The Outlets shapefile is now populated with all of the necessary points for the next step.




8. GRAIP toolbar-> *Preprocessor*-> *Create TauDEM Stream Network*. Under *Select Outlets Shapefile*, navigate to the location of the Outlets shapefile and select it. When asked if it is OK to overwrite files, click *Yes* (it will ask this four times).
    a. The stream network shapefile that was created by TauDEM has been deleted and replaced with this new stream network shapefile that is the same, except that the streams are split at the road-stream intersections.
9. GRAIP toolbar-> *Preprocessor*-> *Resample DEM*.
    a. Check to make sure that *DEM* (under *Input*) is correctly located.
    b. Check to make sure that *DEM Interpolated to a Finer Scale* will be saved to the right place.

**The second method, for when you will not complete the habitat segmentation analysis. This step replaces steps 2-7, above:**

2. Hawth's Tools toolbar-> *HawthsTools* menu-> *Vector Editing Tools*-> *Intersect Lines (make points)*.
    i. For *Line/poly layer*, use the drop down to select the RoadLines layer.
    ii. For *Intersect line/poly layer*, select the demnet layer.

**iii.** For *Output*, click the button to the right of the field, navigate to the same location as the rest of the shapefiles, name the file "Outlets," click *Save*, and then *OK*.

**iv.** The new shapefile is composed of the points at which the roads intersect the stream network.

**b.** Make sure all of the points created are on valid road-stream intersections.

**c.** Start editing and select the folder with the Outlets shapefile. Set the *Target* to the Outlets layer.

**d.** Zoom in as close as possible on a point on the main stream, downstream from all of the roads. This should be pretty far downstream.

**i.** Use the *Sketch Tool* to create a point directly over the stream network line.

**e.** Save the edits and stop editing. The Outlets shapefile is now populated with all of the necessary points for the next step.

**The variation on the second method, for use if Hawth's Tools does not work. This step replaces steps 2-7, above:**

**2.** Use ArcCatalog to create a new shapefile called "Outlets" in the workspace with the rest of your shapefiles.

**i.** Right-click in the shapefiles folder-> *New*-> *Shapefile…*

**ii.** Name it "Outlets," and select *Point* as *Feature Type*.

**b.** Add the Outlets shapefile to ArcMap. Note that it does not have any points in it.

**c.** Start editing and select the folder with the Outlets shapefile. Set the *Target* to the Outlets layer.

**d.** Zoom in as close as possible on each road-stream intersection.

**i.** Use the *Sketch Tool* to create a point directly over each road-stream intersection.

**e.** Zoom in as close as possible on a point on the main stream, downstream from all of the roads. This should be pretty far downstream.

**i.** Use the *Sketch Tool* to create a point directly over the stream network line.

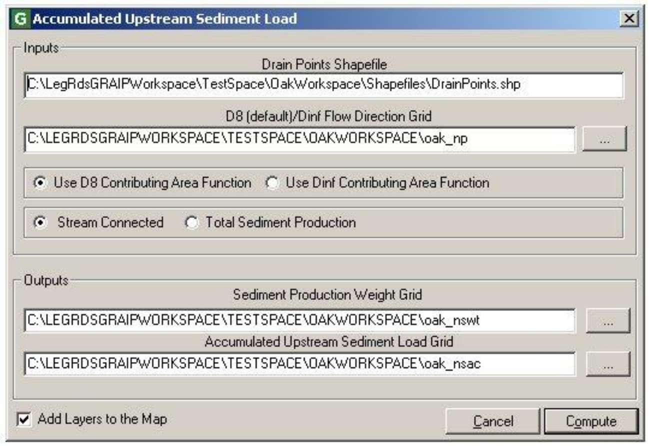
**f.** Save the edits and stop editing. The Outlets shapefile is now populated with all of the necessary points for the next step.

## The Road Surface Erosion Analysis Menu

The six tools under the *Road Surface Erosion Analysis* menu must be run from top to bottom.

1. Open the GRAIP file.
2. GRAIP toolbar-> *Road Surface Erosion Analysis*-> *Road Segment Sediment Production*.
    a. Ensure the RoadLines layer is properly located in the *Road Shapefile* field.
    b. Ensure that demr is properly located in the *DEM Interpolated to a Finer Scale* field.
        i. If this field is blank, demr has not been added to the map. Navigate to demr and select it.
    c. Click *Compute*.
    d. Open the Attribute Table for the RoadLines layer to ensure that the *Length*, *Slope*, *SedProd1*, *SedProd2*, *UnitSed*, *TotSedProd*, *TotSedDel*, and *UnitTotSedProd* columns are populated. The final two columns (*TotSedDel* and *UnitTotSedProd*) may have some cells with a zero.
3. GRAIP toolbar-> *Road Surface Erosion Analysis*-> *Drain Point Sediment Accumulation*.
    a. Ensure that the RoadLines and DrainPoints shapefiles are correctly located in the *Road Shapefile* and *Drain Points Shapefile* fields, respectively.
    b. Click *Compute*.
    c. Ensure that the *SedProd*, *ELength*, *UnitSed*, and *SedDel* columns are populated in the DrainPoints Attribute Table. The *SedDel* column may be largely zeros.
4. GRAIP toolbar-> *Road Surface Erosion Analysis*-> *Accumulated Upstream Sediment Load*.
    a. Ensure that the DrainPoints shapefile is correctly located in the *DrainPoints Shapefile* field, and demp is correctly located in the same folder as the TauDEM files in the *D8(default)/Dinf Flow Direction Grid* field.
    b. Ensure that *Use D8 Contributing Area Function* and *Stream Connected* are selected.

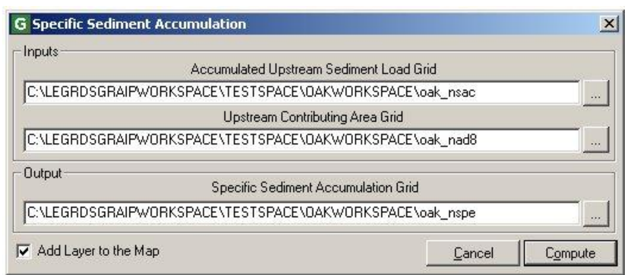
**c.** Check to see that the two outputs (demswt and demsac) will be saved to the correct folder. If you have to change the folder, do not change their names.




**d.** Click *Compute*.

**e.** Make sure the two grids are reasonable.

**5.** GRAIP toolbar-> *Road Surface Erosion Analysis-> Accumulated Upstream Specific Sediment*.




**a.** Ensure demsac and demad8 are correctly located in the *Accumulated Upstream Sediment Load Grid* and *Upstream Contributing Area Grid* fields, respectively.

**b.** Ensure the *Output* grid (demspe, in the *Specific Sediment Accumulation Grid* field) will be saved to the correct folder, as above.

**c.** Click *Compute*.

**d.** Ensure that the grid is reasonable.

**6.** GRAIP toolbar-> *Road Surface Erosion Analysis-> Upstream Stream Sediment Input*.

**a.** Ensure demfel, demsac, demad8, and demnet are properly located in their respective fields (*Pit Filled DEM*, *Accumulated Upstream Sediment Load Grid*, *Upstream Contributing Area Grid*, and *Stream Network Shapefile*, respectively).

**b.** Click *Compute*.

c. Ensure that the *SedAccum* and *SpecSed* columns are populated in the stream network layer Attribute Table. Both columns may be mostly zeros, depending on how many stream network segments are affected by the roads.

**7.** GRAIP toolbar-> *Road Surface Erosion Analysis*-> *Direct Stream Sediment Input*.

   **a.** Ensure that the *Input* fields are correctly populated, as above in step 6a.

   **b.** Click *Compute*.

   **c.** Ensure that the SedDir and SpecSedDir fields are populated in the stream network Attribute Table. Both columns may be mostly zeros, depending on how many stream network segments are directly affected by the roads.

## Running SINMAP

The SINMAPData folder is automatically created in the same directory as the DEM you base the analysis on for all of its files and grids. Use the same DEM that has been used all along for the GRAIP process, and is therefore the DEM that is located in the folder with all of the TauDEM files and grids.

**1.** Open ArcMap or a new map file. SINAMP toolbar-> *Initialization*-> *Select DEM Grid For Analysis*.
   **a.** Navigate to the correct DEM, select it, and click *Add*.
   **b.** The selected DEM will be added to ArcMap, and the SINMAPData folder will be created under the same directory as the DEM.
**2.** SINMAP toolbar-> *Initialization*-> *Make Single Calibration Region Theme*
   **a.** Various parameters can be changed so that the stability index grid is more accurate for the specific area being analyzed in this step. The defaults are initially fine.
   **b.** Click *OK*.
   **c.** The calibration grid (demcal) and its text file (demcalp) are created, added to ArcMap, and saved to the SINMAPData folder.
**3.** SINMAP toolbar-> *Grid Processing*-> *Compute All Steps*
   **a.** No further input is necessary.
   **b.** Four grids are created and added to ArcMap (demfel, demang, demslp, and demsca), and saved to the SINMAPData folder.
**4.** SINMAP toolbar-> *Stability Analysis*-> *Compute All Steps*
   **a.** No further input is necessary.
   **b.** The final two grids (demsi and demsat), as well as a series of text files (demrtp, demlsf, and demstat) are created and added to ArcMap. A statistics window (*S A Plot*) appears. The grids are saved to the SINMAPData folder.
      **i.** The *S A Plot* can be generated easily on its own, so you can close this window. Go to *Stability Analysis*-> *SA plots*.

## The Mass Wasting Potential Analysis Menu

The eight tools under the *Mass Wasting Potential Analysis* menu heading must be run in order from top to bottom. These steps can be undertaken only after SINMAP has been run.

**1.** Open ArcMap or a new map window and open the GRAIP file (the .graip).

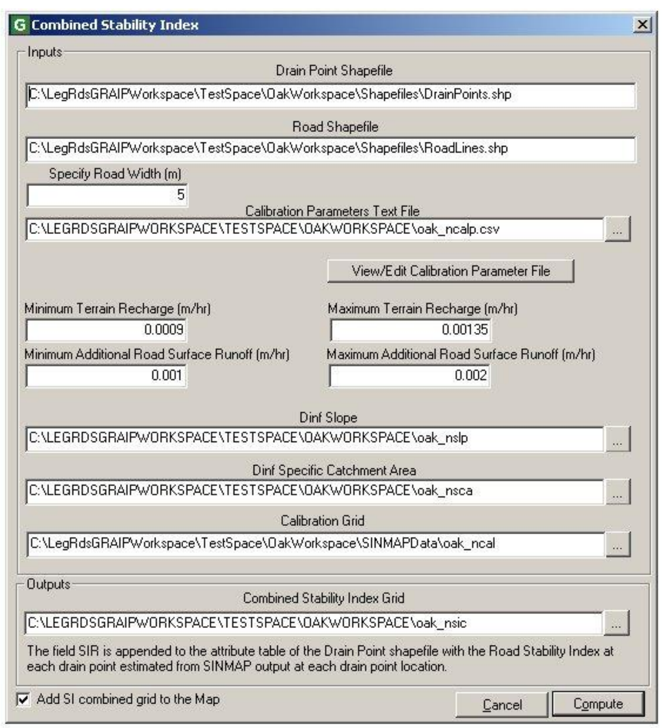
**2.** GRAIP toolbar-> *Mass Wasting Potential Analysis-> Stability Index*

  **a.** Ensure that the DrainPoints shapefile and stability index grids are correctly located, and click *Compute*.

  **b.** Check that the *SI* column has been populated in the DrainPoints Attribute Table. There should not be any zero values.

**3.** *Mass Wasting Potential Analysis-> Select Calibration Region Grid->* navigate to the SINMAPData folder created previously-> select the calibration grid (demcal)-> click *Add*. The calibration region grid is added to ArcMap.

**4.** *Mass Wasting Potential Analysis-> Combined Stability Index*




  **a.** Ensure that the DrainPoints and RoadLines shapefiles are correctly located. Ensure that the fields *Calibration Parameters Text File*, *Dinf Slope*, *Dinf Specific Catchment Area*, and *Calibration Grid* are correctly populated and located (demcalp.csv, demslp, and demsca from the TauDEM folder, and demcal from the SINMAPData folder, respectively).

**b.** The following are default parameters:

**i.** *Specify Road Width (m)* is 5.

**ii.** *Minimum Terrain Recharge (m/hr)* is 0.0009.

**iii.** *Maximum Terrain Recharge (m/hr)* is 0.00135.

**iv.** *Minimum Additional Road Surface Runoff (m/hr)* is 0.001.

**v.** *Maximum Additional Road Surface Runoff (m/hr)* is 0.002.

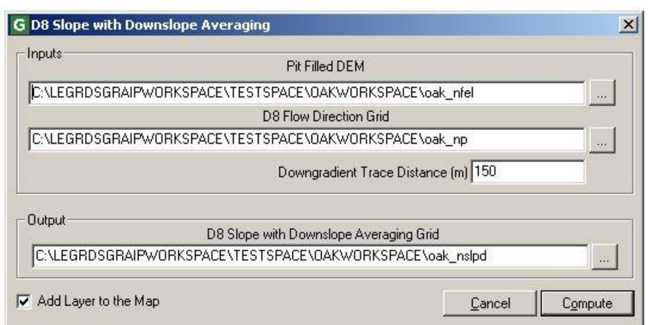
**c.** You can edit additional parameters by clicking on the *View/Edit Calibration Parameter File* button. The defaults are all generally fine.

**d.** Ensure that the *Combined Stability Index Grid* will be saved to the correct place. Do not change its name.

**e.** Check *Add SI combined grid to map* and click *Compute*.

**f.** Five grids are created (demsic, demrmin, demrmax, demrdmin, and demrdmax). The last four grids are not added to ArcMap and are saved to the same place as the TauDEM files. These files are intermediary (i.e. they are used by the *Combined Stability Index* function and nothing else)

**5.** *Mass Wasting Potential Analysis-> D8 Slope with downslope averaging*




**a.** Ensure that the *Pit Filled DEM* (demfel) and *D8 Flow Direction Grid* (demp) are correctly located.

**b.** The default value for the *Downgradient Trace Distance (m)* field is 150.

**c.** Ensure that the *D8 Slope with Downslope Averaging Grid* will be saved to the correct place. Do not change the name.

**d.** Click *Compute*. The layer will be added to the map.

**6.** *Mass Wasting Potential Analysis-> Slope at Drain Point*

a. Ensure that the *Drain Points Shapefile* (DrainPoints) and the *D8 Slope with Downslope Averaging Grid* (demslpd) are correctly located.

b. Click *Compute*.

c. Check to make sure the *Slope* column is populated in the DrainPoints Attribute Table. There should not be any zero values.

7. *Mass Wasting Potential Analysis-> Erosion Sensitivity Index*

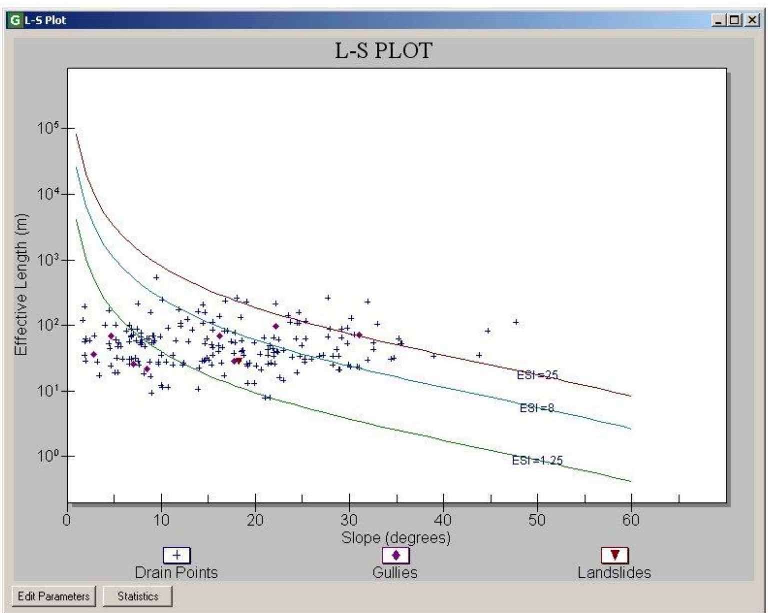
    a. Ensure that the *Drain Points Shapefile* is correctly located.

    b. The default for the *Exponent Alpha* field is 2.

    c. Click *Compute*.

    d. Check to make sure the *ESI* column in the DrainPoints Attribute Table is populated. There may be some zero values, which are orphan drain points. This function sometimes takes a few moments to populate the table.

8. *Mass Wasting Potential Analysis-> Length Slope Plot*




    a. This generates a graph of effective length vs. slope of the drain points, with ESI lines super imposed. Note that the Y-axis is logarithmic.

    b. This figure can be used to pick threshold values of ESI, above which, the risk of gullying increases.

    c. Nothing is added to any table, created, or saved in this step.

9. *Mass Wasting Potential Analysis-> Stream Blocking Index*

    a. Ensure that the *Drain Points Shapefile* is correctly located.

  b. Click *Compute*.
  c. Ensure that the *PipeDiaToChanWidthRatio*, *PipeDiaToChanWidthScore*, *SkewAngle*, *SkewAngleScore*, and *SBI* columns in the DrainPoints table are populated at stream crossings. Most of the values will likely be zeros, because most drain points are not stream crossings.

**10.** You can leave this map file open for the next step.

## The Habitat Segmentation Analysis Menu

There are two tools under the *Habitat Segmentation Analysis* menu that should be run from top to bottom. These steps may not be necessary if you are not conducting a watershed-wide study, or if another approach is being used.

**1.** If ArcMap is not open, open it and open the appropriate .graip.

**2.** GRAIP toolbar-> *Habitat Segmentation Analysis-> Fish Passage Barrier*

- **a.** Ensure that the DrainPoints shapefile is correctly located in the appropriate *Inputs* box.
- **b.** You can change the parameters that define a blocked passage.
    - **i.** The following are default parameters:
        - *Crossing Slope Sp (%)* is 2.
        - *Pipe/Channel Width ratio w*p* is 0.75.
        - *Outlet Drop ODp (ft)* is 0.8
        - *Outlet Drop to Pool Depth ratio* is 1.125.
- **c.** Click *Compute*.
- **d.** Check to make sure that the *Barrier* column is populated with 0-2 at the stream crossings in the DrainPoints Attribute Table. 0 is a blocked passage to all species, 1 is blocked to some species, and 2 is clear to all species.

**3.** *Habitat Segmentation Analysis-> Fish Habitat Segmentation*

- **a.** Ensure that the *Stream Network Shapefile*, *Matched Stream Crossings Shapefile*, and *Drain Points Shapefile* are properly located. The *Matched Stream Crossings Shapefile* is MatchSX, created in the preprocessing step, above.
- **b.** In the *Barriers to Fish Passage at Stream Crossings* field, select whether you would like to use both blocked and possibly blocked barriers, or only blocked barriers to define when a stream crossing is blocked by selecting the appropriate dot.
- **c.** Click *Compute*.
- **d.** Check to make sure that the *HabPatchID* column is appended and populated in the stream network shapefile.